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# Mobile Delivery of Health Information for People with Mild Cognitive Impairment

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**Abstract.** The design of a smartphone application (app) for promoting healthy lifestyle choices has been investigated for people with mild cognitive impairment. The app was designed to provide health-related messages and assist users to keep track of activities such as walking, eating and drinking water. A reward scheme with gold, silver and bronze awards was incorporated as a means of assisting user motivation. Responses to the app and user feedback were gathered for purposes of evaluation and improvement. Outcomes indicate that the approach has some potential and could have good implications for encouraging positive health-related behaviour change in this population, hence prompting further investigation and development of the concept.

**Keywords.** Mild Cognitive Impairment, health information delivery, mobile app, healthy lifestyle choices

## 1. Introduction

Health promotion information should be available to everyone, but barriers exist for certain groups. People with mild cognitive impairment (MCI) [1] may have difficulty in accessing health promotion messages, for example, which creates a health inequality for them. People with MCI commonly have problems with information processing and recall, which can have a negative impact on their ability to follow such promotional messages. One approach to this problem could be to design a mobile smartphone application (app) to present health information in an accessible manner for this population group.

Existing health promotion applications available for mobile smartphones are generally difficult for people with MCI to access due to complexity. The intention here is to investigate the design of a mobile app which would be accessible to people with MCI and help them to follow health messages such as those provided by an official public health organisation. The app would allow users to keep track of activities such as walking (how many steps taken), eating (fruit and vegetable intake) and drinking (glasses of water consumed). Motivation to adopt a healthier lifestyle could be assisted by rewards in the form of gold, silver and bronze awards for performance of activities, rewards which the app could retain and accumulate to remind the user of their progress towards the goal of healthy living.

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## **2. Background**

Knight et al. [2] reviewed Apple and Android app stores, seeking mobile health apps for chronic disease management and prevention with a focus on evidence-based physical activity apps and technological features which might lead to improved health outcomes. The review showed a marked shortage of evidence-based physical activity apps and hence the need for development of this kind of application. Another study [3] looked into the increasing number of web applications and whether these promote a healthier lifestyle. It indicated that the use of a web application had the possibility of promoting a positive healthy lifestyle, although further research on a larger scale was required.

Dallinga et al. [4] aimed to determine whether there was a relationship between the use of a mobile app and changes in health behaviour in short and long distance runners during preparation for a sporting event. Outcomes showed that the use of a mobile app had a positive effect on their preparation. The study suggested that mobile apps could promote a healthy lifestyle; however more research was required to confirm this. The group studied in their research did not have MCI, but the outcomes can be seen as an indication that a mobile app could have a positive effect on an individual's lifestyle. A study [5] to examine health app use among mobile phone owners in the United States showed that a substantial number of owners did not use health apps, and that many who had downloaded them subsequently deleted them again. Data entry burden was one reason given for this.

Further investigation here sought out relevant applications in the Google Play and Apple iTunes stores but found no applications which were accessible to people with MCI that related to the relevant public health messages. Whilst there were some apps which allowed users to track steps and activity time, such as Google Fit [6] or S Health [7], these could be complicated and confusing for a user with MCI. Applications were not found to focus on relevant official public health guidelines for aspects such as steps completed, physical activity time, glasses of water and fruit and vegetable intake.

There is thus some evidence to suggest that a mobile data-gathering app could have a positive effect on a person's health-related lifestyle. There is also a need for a relevant mobile app to promote public health guidelines which could be used by people with mild cognitive impairments, as this population group is currently less well provided for. The work reported here therefore set out to investigate this area of need.

## **3. Specification**

A common feature of MCI is difficulty in retaining information and this means that individuals can struggle to keep track of their progress towards meeting guidelines. The intention here is to try to help them to keep track of progress. The requirements for the app were developed through inter-disciplinary collaboration between software engineers and a specialist speech and language therapist. The app would keep track of steps walked, fruit and vegetables eaten, glasses of water consumed and activity time. Because it is important to reduce data entry burden where possible, a simple method of data entry or data gathering (e.g. automatic step counting) was needed. The app would also notify the user if they had not yet accessed it that day and remind them to input information. A reward system would be included to help motivate the user to participate; the user would be awarded "stars", for example, for meeting targets on any

day, and “trophies” would acknowledge the user for continually winning stars. The application was to be developed for the Android platform, chosen due to its wide popularity [8] and relatively competitive cost.

#### 4. Design

It was important that the design should be kept simple and easy to use. Difficulty processing linguistic information can be associated with MCI and so symbols are often used to assist communication. It was decided to augment labels with icons throughout the app to make each screen and the items on it easily recognisable for the user. Small icons and displays can be problematic for some (e.g. older) viewers [9], so care had to be taken over the design of display layouts and symbol sizes used, and also cognitive demands placed on users [10].

The different daily achievement levels of the “star” reward system are displayed in Table 1. Users may begin by earning bronze stars then aim to improve their results in order to earn higher (silver and gold) stars.

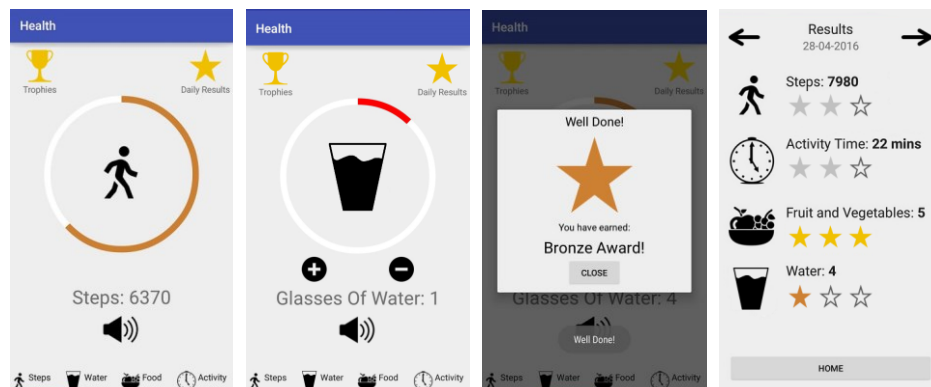
**Table 1.** Star (Bronze, Silver and Gold) rewards with their associated daily achievement levels.

	<b>Bronze</b>	<b>Silver</b>	<b>Gold</b>
Steps	5000	7500	10000
Fruit & Vegetables	2	4	5
Physical Activity	10 minutes	20 minutes	30 minutes
Water (glasses)	4	6	8

##### 4.1. Screen Design

After low-fidelity design prototyping, screen layouts were developed and refined. The Home Screen (Figure 1 (left)) displays results achieved for the day in a particular category (e.g. steps made) using a circular progress bar coloured according to the award level (bronze, silver or gold) achieved thus far on that day. The user can swipe through the different categories or choose one to view using the icons at the foot of the screen.

The app collects data for steps made and elapsed activity time from Google Fit [6], while data for fruit, vegetable and water consumption are entered directly by the user. When the user consumes a glass of water or a portion of fruit or vegetables they press a “plus” button on the relevant screen to increase by 1 the total for that day (Figure 1 (centre-left)). If an error is made the user can press a “minus” button to reduce the total displayed. The “plus” and “minus” buttons make different sounds when pressed to help the user differentiate between them. All data entered is stored in the app along with achievements and rewards earned. If a new reward (e.g. star) is achieved a pop-up window displays a congratulatory message to the user (Figure 1 (centre-right)). To make results more accessible to users there is optional audio output. Pressing the audio (loudspeaker) icon makes the app emit a congratulatory speech message with the results achieved for that category on that day.



**Figure 1.** Four screenshots showing a 'Steps' Home Screen (left), Water Data Entry Screen (centre-left), Bronze Award Pop-up (centre-right) and the Daily Results Screen (right).<sup>3</sup>

Notification messages were designed to remind users to use the application on a daily basis, as users with MCI can have memory problems. Example notifications are “Have you had a glass of water today?” and “Have you eaten any fruit and veg today?”.

#### 4.2. Daily Results

A day's results are shown on a daily results screen (Figure 1 (right)). Results for each category are displayed using stars which are coloured according to the award achieved for that day. A single bronze star means that bronze level has been achieved for that category, while two silver stars mean that silver level has been achieved and three gold stars mean that gold level has been achieved. The achievement level is thus indicated by both the number and colour of the stars displayed. This makes it easy for the user to see how well they have done that day. Neutral stars, with outlines but no body colour, act as empty placeholders on the results screen reminding the user that further coloured stars can be earned and placed in these positions. Arrows at the top of the screen allow the user to scroll back and forth through results from previous days. There is also the trophy system which rewards the user for consistency in meeting daily targets; gold, silver and bronze trophies can be won and accumulated and they can be displayed on a screen of their own.

## 5. Methods

Three participants with MCI (2 female and 1 male, age range 40-59 years) were recruited and introduced to the app and its various icons. They were asked to confirm that the icons were easily understandable. A smartphone (Sony Experia M4 running Android version 5.0) was allocated to each participant and its operation and that of the app were demonstrated and explained. Each participant was asked to perform various tasks on it to familiarise with it. Participants were then given three weeks to use the app,

<sup>3</sup> Attributions for Figure 1: "[Sport, walking icon](#)" by [Ivan Boyko](#) / CC BY 3.0 ; "[Fruit, healthy, strawberry icon](#)" by [Hosting Guia](#) / CC BY 3.0 ; "[Clock, event, time, timer, watch icon](#)" by [Alex Talalueva](#) / CC BY 3.0 . The "[Add, plus icon](#)" ([Yannick Lung](#)); "[Delete, minus, remove icon](#)" ([Yannick Lung](#)); "[Audio, device, loudspeaker, sound, speaker ...](#)" ([Xinh Studio](#)) are free for commercial use. Other icons © The Authors, 2016.

after which they were invited to give feedback about it. This involved completing a short questionnaire, including a System Usability Scale (SUS) [11], to evaluate the usability of the application; there was also a semi-structured interview where participants were asked about the design and their thoughts on the app. They were encouraged to elaborate with further feedback. The overall focus was on what the participants thought about using the application and whether they felt it was a positive experience and had potential for encouraging a healthy lifestyle.<sup>4</sup>

## 6. Results

The results from the SUS gave an average score of 71.7 which in general use would be considered to represent above-average usability. The participants also gave feedback on their experiences with the app. Participant A *“enjoyed using the app”* and said this was an *“app they would definitely use”*. They particularly liked being able to compare step counts with a friend who also had a step counter. Participant A asked that there should be more notifications given by the app, with audio alerts. They felt that the application held the possibility to improve their lifestyle from a health perspective but would need a longer period of use to confirm this. Participants B and C both indicated that they liked the trophy (reward) section and that this motivated them to use the app more. Participant B stated that as a result of using the app they would often walk rather than getting the bus in order to increase their step count. Participant C said they found that they were drinking more water as a result of using the app. Participant C was less dexterous and sometimes had difficulty in entering information into the device; suggestions for increasing the button size on the app and providing audio feedback for button activation arose from this. A further suggestion from the feedback was that a pop-up could appear when the app was opened to remind the user of its range of available features. Increasing the number of notifications was also suggested.

## 7. Discussion

The outcomes described here indicate that the app had acceptable usability and could have a positive effect on certain health-related activities of people with mild cognitive impairments. There was evidence of use of the app having motivational value and a positive effect on the actions of the participants. The reward system (stars and trophies) was endorsed. There was a suggestion that a competitive spirit between friends based on their performance and rewards could encourage further achievement.

Some modifications were made to the app in response to feedback received. Button size was increased because participants were finding buttons rather small and difficult to press when they were entering information. Audible beeps were also added to signify button activation. In order to alert users to the arrival of notifications, a vibration alert was incorporated.

The development aimed to motivate individuals with MCI to improve their health-related activities through a mobile smartphone app and this initial work has shown

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<sup>4</sup> Approval for the work was given by the University of Dundee Computing Ethics Committee, confirming that the work would be conducted within the University Guidelines for ethical practices in research and the Computing Code of Practice for Research involving Human Participants.

some potential. This supports the original aims of the work. More research is required to confirm this, however, in particular in the area of evaluation where a larger scale experiment is required. A larger number of participants would be involved and the scope of the work could also be increased to include a wider range of ages and abilities. This would give a clearer indication of the potential of the approach. It would also be appropriate to evaluate long-term user engagement with the app and its effects on health-related behaviour.

## 8. Conclusions

A prototype smartphone app has been designed to deliver health information messages for people with mild cognitive impairments (MCI) in order to help them keep track of their health-related activity and provide motivation to adopt healthier behaviour. The outcomes indicate that the app had acceptable usability and could have a positive effect on certain health-related behaviours of people with MCI. The project set out to investigate this area and has shown some potential for success, which encourages consideration of further development and evaluation.

Some possibilities for future improvements to the app include adding a calendar to assist the user in navigating through stored results from the past, and extending the trophy section in a study of the motivational effects of rewards. Finding out more about what motivates individuals to use the app and increase their achievement levels could be beneficial.

The outcomes of this work encourage further investigation in the area, including further experimentation to yield fuller assessment of its potential, and the development of more features and facilities. The promotion of healthy lifestyle choices among people with mild cognitive impairment could benefit greatly from such research.

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